DEFENSE HEALTH BOARD
FIVE SKYLINE PLACE, SUITE 810
5111 LEESBURG PIKE
FALLS CHURCH, VA 22041-3206

SEP 23 2011

FOR: JONATHAN WOODSON, M.D., ASSISTANT SECRETARY OF DEFENSE (HEALTH AFFAIRS)

SUBJECT: Defense Health Board Recommendation Memorandum Pertaining to Automated Neuropsychological Assessment Metrics 2011-10

Background:

In December 2008, the Deputy Assistant Secretary of Defense for Force Health Protection and Readiness (DASD(FHP&R)) requested that the Defense Health Board (DHB) examine the following:

a. Assess the effectiveness of baseline pre-deployment neurocognitive testing using the Automated Neuropsychological Assessment Metrics (ANAM) tool to determine the neurological deficits in function following a traumatic brain injury (TBI) event.

b. Determine the added value of supplemental sections on language, memory, attention, executive function, and cognition.

c. Examine the value of including the symptoms and patient history, a mood and sleepiness scale, as well as, measures of response inhibition and effort.[1]

The TBI External Advisory Subcommittee held a meeting on March 24, 2009, during which the subcommittee members discussed current data and received presentations from subject matter experts (SMEs). Briefings were provided by representatives from the Office of the Assistant Secretary of Defense for Health Affairs (OASD(HA))/FHP&R; Defense and Veterans Brain Injury Center (DVBIC); and the Office of the U.S. Army Surgeon General.[2]

The Board suspended its examination of this issue due to the expiration of the TBI External Advisory Subcommittee member appointments. Following the March 7-8, 2011 DHB meeting, Dr. Woodson renewed the charge to the Board and the task was assumed by the Psychological Health External Advisory Subcommittee. The Psychological Health External Advisory Subcommittee held a meeting on May 9, 2011, during which the subcommittee members discussed current data, identified SMEs and the way ahead.[3] The Psychological Health External Advisory Subcommittee then held a meeting on June 16, 2011. Briefings were received from representatives from the following: DVBIC; the Defense Centers of Excellence for Psychological Health and TBI; and OASD(HA)/FHP&R.[4] The Board approved these recommendations by unanimous vote in an open session held on August 8, 2011.

SUBJECT: Defense Health Board Recommendation Memorandum Pertaining to Automated Neuropsychological Assessment Metrics 2011-10

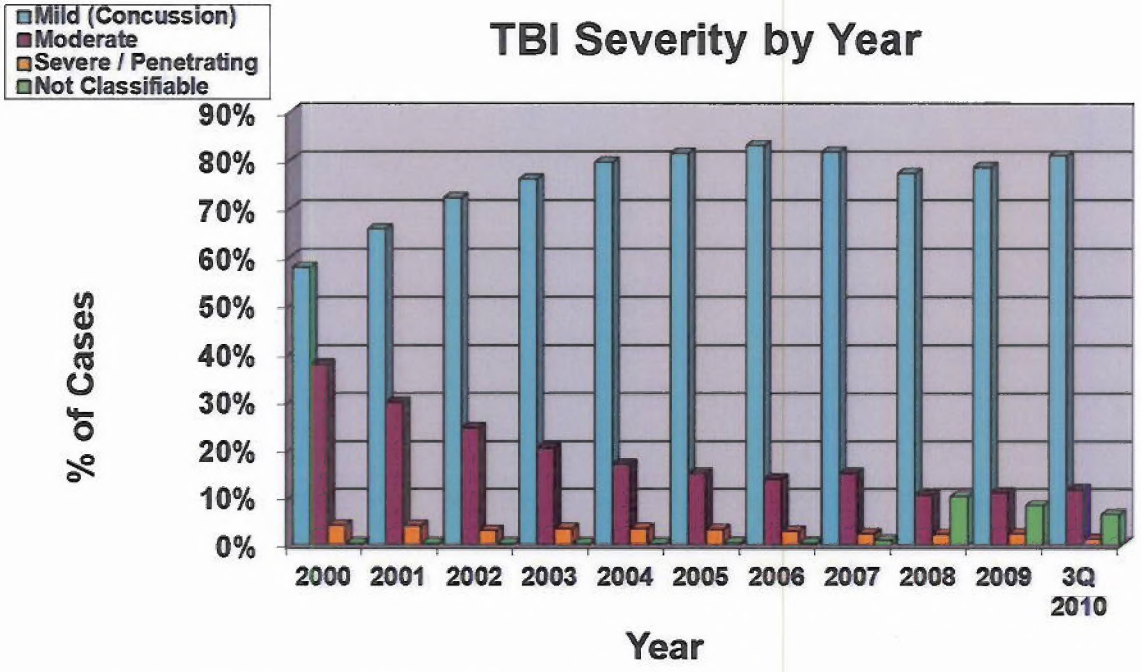
Discussion:

TBI has been a public health concern for quite some time. In the United States 1.5 million people suffer traumatic brain injuries annually.[5] Mild TBI (mTBI) has been recognized by Congress as a public health issue as early as 2000. In response to this concern, Congress passed the *Children's Health Act of 2000,* to which the Centers for Disease Control and Prevention responded by recommending appropriate methodological strategies to obtain data on the incidence and prevalence of mTBI.[6] TBI has since become the signature injury associated with the current conflict in Iraq and Afghanistan. Data from the DVBIC demonstrates that the incidence for TBI has increased (Table I) from a baseline line of 10,963 cases in 2000 to 30,233 cases in 2010. However the incidence of both moderate and severe TBI has steadily declined over the past decade (Figure 1) with the remaining bulk of injury attributed to concussions.

TABLE I

TBI Diagnoses (all severities) 2000–2010

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL
10,963	11,830	12,470	12,898	13,312	12,192	16,946	23,160	28,555	29,223	30,703	202,281



Source: http://www.dvbic.org/TBI-Numbers.aspx

Concussion severity is usually graded at the time of injury based on the duration of symptoms, with emphasis on loss of consciousness, amnesia, and confusion.[7] However there is no empirical basis that links grading with outcomes.[8] Acute concussive symptoms may resolve within minutes. However, long term post-concussive symptoms may persist.[9] Of particular concern in operational settings is that post-concussion syndrome includes cognitive impairments, such as slowed reaction time and information processing speed. Return to duty determinations are critical because of the immediate post-concussion effects and the risk of a second concussive injury. If the concussions are contiguous it may lead to death or with recurring concussions, sequela may include chronic cognitive impairment or emotional dysfunction.[10,11] There is also clinical evidence suggesting that the brain is metabolically vulnerable for a number of days following a concussion. [12]

In 2006, the Armed Forces Epidemiological Board (AFEB) noted that "it is timely for the DoD to be a leader in tackling the issue of TBI". The AFEB went on to underscore the importance of a standardized method of concussive assessment that could be used in the field. The AFEB also recommended the implementation of a baseline screening tool to enhance the utility of post-injury formal neuropsychological testing.[13]

Computerized reaction time is a particularly sensitive measure for concussion.[14] The ANAM was developed by the DoD Joint Working Group on Drug Dependent Degradation of Military Performance. The tool is a brief, repeatable, and automated cognitive measure that provides the opportunity for longitudinal individual assessments.[15] The ANAM is comprised of a battery of computerized neuropsychological tests. The 20 minute tool consists of six subtests: Simple Reaction Time (SRT), Matching to Sample (MSP), Mathematical Processing (MTH), Spatial Processing (SPD), Sternberg Procedure (STN), and the Continuous Performance Test (CPT). The ANAM data is analyzed by using a score based on the number of correct responses per unit of time. The score is a product of both speed and accuracy providing a single efficiency score. ANAM uses a pseudorandomization procedure to generate items so that each test session contains a different combination of items thereby minimizing practice effects.[15]

In response to the National Defense Authorization Act (NDAA) for Fiscal Year 2008, the Department of Defense (DoD) began mandatory pre-deployment neurocognitive testing of Service members.[16] A DoD expert consensus panel selected the ANAM as an interim computerized neurocognitive assessment tool in order to identify and monitor functional changes within Service members, pending further evaluation of other Neurocognitive Assessment Tools (NCATs).[17] Other NCAT batteries include: BrainCheckers™, CNS Vital Signs™, CogSport®, HeadMinder™ Cognitive Stability Index, and ImPACT™.[18] Although the terms "ANAM" and "NCAT" are often used interchangeably, it is important to note that NCAT is the process whereas ANAM is the battery currently being used for NCAT.[19] While studies comparing available NCATs are limited, DVBIC has received permission to conduct a comparison study, assessing the reliability of various instruments and comparing data from different available batteries to traditional measures.[19]

ANAM proved to be an effective adjunct to assist in post-concussion return to duty determinations but had limited value as a population based post-deployment screening measure.[4]

Representatives from DoD provided briefings to Congress regarding the inefficiencies of ANAM when used as a congressionally-mandated universal post-deployment measure. Congress responded by revising the post-deployment neurocognitive assessment requirements and broadening the language to allow for more appropriate post-deployment testing.[20] According to the DVBIC, as of March 31, 2011, over 856,000 Service members have been baseline tested with ANAM. Providers can request individual baseline data from the DVBIC to aid in return to duty evaluations. Thus far they have received 10,206 requests; 2,668 of these originating from theater and an additional 387 from Germany. The Defense Health Information Management System has processes in place to support an enterprise wide capability for ascertainment of ANAM baselines from theater.

It is important to note that the diagnosis of concussion is established by the identification of an event or history of an injury followed by an alteration of consciousness. Procedures employed post-injury, to include imaging studies, balance testing, neurological exams or cognitive assessment tools (for example, ANAM), are completed to assess the individual who was concussed not to diagnose the concussion.

ANAM has been used in serially testing and precisely measuring cognitive processing in a variety of areas, including neuropsychology, pharmacology, as well as military operational, undersea, and sports medicine.[21] A prospective study involving cadets at the United States Military Academy (USMA) used the ANAM to determine the duration of cognitive impairment following sports concussion. At the start of the academic year, 729 first-year cadets were given the ANAM. Of the 729, sixty-four were concussed while participating in an intramural boxing program. Omnibus F tests were performed to determine the main effects of group and time intervals and the interaction effect of group by time for each ANAM subtest. The SPD interaction term was sensitive to concussion ($F[4,41.4]=2.66$, $P=0.04$). The MTH subtest trended toward significance ($9F[4,79.4] = 2.38$, $P=0.06$) and the other components of the battery failed to show a significant interaction. Both the SPD and MTH improved over time consistent with recovery during the 3-7 day interval post-injury.[22] In an earlier study, also at the USMA, in which the subjects served as their own controls, both the SRT and CPT scores had significantly declined and subsequently recovered following a concussive event.[23]

In addition to the association of concussion and decreased performance on a single ANAM test, one group of investigators found that even with an initial score consistent with baseline measurements, repeat testing yielded erratic results in those with TBI. ANAM also correlates with other traditional neuropsychological measures. Consistent one-to-one associations were found between specific ANAM subtests with traditional neuropsychological tests. Examples include strong associations between the Digit Symbol and MTH, Symbol Search and MSP, and Hopkins Verbal Learning Test Immediate Learning and the STN. MTH has the most significant overlap with traditional pen and paper measures and demonstrated a stronger relationship with post-concussive symptoms.[24]

ANAM has also been used to assess cognitive impairment in a number of non-traumatic disorders. Change in cognitive impairment has been assessed using the ANAM in patients with Multiple Sclerosis, Systemic Lupus Erythematous, Parkinson's Disease, and Alzheimer's Dementia.[25]

ANAM use, to aid in return to duty determinations, in combat related post-concussion Service members is increasing. One study compared concussive symptoms, cognitive performance and psychological symptoms between acute blast versus non-blast induced mTBI.[26] This study examined 103 military personnel and three civilian contractors diagnosed with mTBI, seen within 72 hours of injury at a combat support hospital in Iraq. Reductions in ANAM accuracy were related to the duration of loss of consciousness and not the mechanism of injury, with ANAM scores improving over time post-event. In an unpublished study also conducted in Iraq involving 71 concussed Service members and 166 controls, ANAM scores in those without a loss of consciousness differed only on the SRT subtest. Those who also experienced a loss of consciousness showed differences on four of the six ANAM subtests.[4] Feedback obtained from theater suggests that ANAM is a valuable tool to assist providers in determining when a Service member can return to duty following a concussion or mTBI particularly when individual rather than population baseline data is employed.[4] Unpublished analysis of 8,002 controls confirmed that individual baseline data is more accurate than population norms for assessing test scores.[27]

However, there is some evidence that the ANAM may be helpful in individuals who are still experiencing symptoms of mTBI in the post-deployment period. In the previously cited unpublished report involving over 8,000 controls, those who remained symptomatic had a greater frequency of low ANAM test scores.[27] In one case report describing two United States Air Force Airmen who were injured in a roadside improvised explosive blast in Iraq in January 2008. Both individuals suffered concussive injuries and developed symptoms consistent with mTBI. Six months after injury, ANAM assessment demonstrated decreased performance in all areas. Following hyperbaric therapy the symptoms resolved coinciding with most ANAM performance returning to pre-injury baseline.[28]

ANAM as a population based post-deployment measure of TBI is not useful. As expected ANAM results are consistent with expected recovery following mTBI. In a study specifically examining the performance of the ANAM in a nonclinical sample of 956 soldiers screened for mTBI after returning from Iraq and Afghanistan there were no associations between poor ANAM performance and the number of lifetime TBIs, the injury severity and the number or problematic post-concussive symptoms.[29]

FINDINGS

1. ANAM has been used in serially testing and precisely measuring cognitive processing in a variety of areas, including neuropsychology, pharmacology, as well as military operational, undersea, and sports medicine.[21] However, ANAM is not intended to diagnose a medical condition and should not be used as a screening or diagnostic tool for a Service member prior to diagnosis.[18]

2. Although sleepiness assessments are part of the current battery, it is not clear how individual results indicating high levels of fatigue are used to modify the remainder of the test procedures. For example, there are no changes to the testing protocol based on a respondent's report of severe fatigue or sleep deprivation.[19]

3. Language problems are typically not affected following mTBI and moreover cannot be evaluated by a computerized self-administered assessment. Thorough assessment of language ability appears to be beyond the scope of a brief assessment, computerized or otherwise.[18]

4. The majority of mTBI events are not related to deployment; therefore, these findings and recommendations related to neurocognitive assessment are relevant to Service members throughout their term of service.[18]

5. Emerging evidence suggests that ANAM may be an effective pre-deployment tool for establishing baseline neurocognitive performance and providing a comparison standard following individual exposure to events that could have a negative impact on neurocognitive performance.[26,28,29] Various independent scientific reports are consistent with this more conservative approach of using NCAT results in individual Service members.[17,30,31]

6. Memory, attention, and effort appear to be embedded in and measured by ANAM.

7. According to DVBIC and the Defense Centers of Excellence for Psychological Health and TBI representatives, using ANAM after an event, either in theater or garrison, is useful in detecting injury and the corresponding neurocognitive deficits when combined with a clinical evaluation, including full neuropsychological evaluation, and compared to that individual's baseline ANAM results.[18,19]

8. While there have been minimal comparisons of brief neuropsychological measures in order to determine which one is best-suited for NCAT, a substantial amount of normative military population data has been collected through the ANAM tool.

    a. Comparisons of brief measures with criterion standard measures (for example, formal psychological testing) are often done in different populations.

    b. Purported differences between brief measures are often small to modest (for example, one may be modestly better on one domain than another).

RECOMMENDATIONS

Based on recent literature and expert opinion regarding the history, research, policy and implementation of ANAM, the Board submits the following recommendations to the Assistant Secretary of Defense (Health Affairs):

1. **Universal post-deployment NCAT for all Service members is not recommended, and will not be, until further research is performed and understood. Instead, it is recommended that NCAT be used selectively for those that have experienced events (for example, trauma) or show symptoms.**

2. **NCAT (currently ANAM) is best used as a targeted instrument to increase the data available for individual-level assessment compared to baseline. It should not be used as a stand-alone diagnostic tool or as a sole population measure.**

3. **Decrements in NCAT scores from pre- to post-deployment should not be interpreted in isolation but should be considered together with events, symptoms, and clinical findings.**

4. **Clinical interpretations of NCAT findings should include other information routinely obtained post-deployment which may themselves affect or be affected by cognitive testing, including depression and PTSD.**

5. **NCAT should not be used alone to determine fitness for duty or deployment, should be done cautiously, and must always be coupled with clinical assessments.**

6. **Due to the substantial amount of ANAM normative data for military populations, as well as the understanding that the decision to replace a brief measure (for example, ANAM) with another (for example, ImPACT™) should be based on significant evidence, changing from ANAM is not recommended at this point. Other batteries do not provide a significant advantage over ANAM that would warrant replacement.**

7. **There does not appear to be an urgent need to add screening measures to the current neurocognitive battery, which can be supplemented during individual clinical assessment with tools available to providers.**

8. **Analyses should be conducted to determine the importance of fatigue or sleepiness for test results.**

9. **Given the limitations of the brief neurocognitive test, specifically testing complex domains such as executive function and cognition is beyond the scope of the ability of the test; however, such domains appear to be embedded in, and measured indirectly by, ANAM.**

10. **ANAM validity and reliability should be continually tested and updated. Other NCAT tools should be evaluated for consideration as alternative pre-deployment neurocognitive measure.**

FOR THE DEFENSE HEALTH BOARD:

Nancy W. Dickey MD

Nancy Dickey, M.D.
DHB President

REFERENCES

1. Memorandum, Office of the Assistant Secretary of Defense for Health Affairs (Force Health Protection and Readiness), Request to the Defense Health Board to Review the Current Pre-Deployment Neurocognitive Assessment Testing Tool. December 2008.

2. Defense Health Board. Minutes of the Meeting of the TBI External Advisory Subcommittee. March 24, 2009; Silver Spring, Maryland.

3. Defense Health Board. Minutes of the Meeting of the Psychological Health External Advisory Subcommittee. May 9, 2011; Bethesda, Maryland.

4. Defense Health Board. Minutes of the Meeting of the Psychological Health External Advisory Subcommittee. June 16, 2011; Arlington, Virginia.

5. Centers for Disease Control and Prevention. Traumatic Brain Injury in the United States: Emergency Department visits, hospitalizations, and deaths. Retrieved 27 July, 2011. http://www.cdc.gov/traumaticbraininjury/tbi_ed.html

6. National Center for Injury Prevention and Control. Report to Congress on Mild Traumatic Brain Injury in the United States: Steps to Prevent a Serious Public Health Problem. Atlanta, GA: Centers for Disease Control and Prevention. 2003.

7. Cantu R. Cerebral concussion in sport: Management and prevention. Sports Medicine, 14(1), 64-74, 1992.

8. Aubry M, Cantu R, Dvorak J, Baumann T, Johnston K, Kelly J, Lovell M, McCory P, Meeuwisse W, Schamach P. Summary and agreement statement of the First International Conference on Concussion in Sport, Vienna 2001. Recommendations for the improvement of safety and health of athletes who may suffer concussive injuries. British Journal of Sports Medicine, 36(1), 6-10, 2002.

9. Mittenberg W, Strauman S. Diagnosis of mild head injury and the postconcussion syndrome. Journal of Head Trauma Rehabilitation, 15(2), 783-791, 2000.

10. Collins MW, Lovell MR, Iverson GL, Canut RC, Maroon JC, Field, M. Cumulative effects of concussion in high school athletes. Neurosurgery, 51(5), 1175-1179, discussion 1180-1181, 2002.

11. Cantu, RC. Second-impact syndrome. Clinics in Sports Medicine, 17(1) 37-44, 1998.

12. Giza CC, Hovda DA. The neurometabolic cascade of concussion. Journal of Athletic Training, 36, 228-235, 2001.

13. Memorandum, Armed Forces Epidemiological Board for the Honorable William Winkenwerder, Jr., MD, Assistant Secretary of Defense for Health Affairs. Traumatic Brain Injury in Military Service Members. August 11, 2006.

14. Hugenholtz H, Stuss DT, Stethem BA, Richard MT. How long does it take to recover from a mild concussion. Neurosurgery, 22(5), 853-858, 1998.

15. Reeves DL, Bleiberg J, Roebuck-Spencer T, Cernish AN, Ivins B, Salazar AM, Harvey SC, Brown FH, Warden D, Schwab K. Reference values for Performance on the Automated Neuropsychological Assessment Metrics V3.0 in an Active Duty Military Sample. Military Medicine, 171(10) 982-994, 2006.

16. Memorandum, Office of the Assistant Secretary of Defense for Health Affairs, Baseline Pre-deployment Neurocognitive Functional Assessment-Interim Guidance. May 28, 2008.

17. Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury. Clinical Recommendation: Indication and Conditions for In-Theater Post-Injury Neurocognitive Assessment Tool (NCAT) Testing. June, 2011. Retrieved from: http://www.dcoe.health.mil/Content/navigation/documents/Indications%20and%20Conditions%20for%20In-Theater%20Post-Injury%20Neurocognitive%20Assessment%20Tool%20Testing.pdf

18. Presentation: ANAM Development and Execution: DoD Clinical Implications for NCAT, to the DHB Psychological Health External Advisory Subcommittee by Ms. Kathy Helmick, June 16, 2011.

19. Presentation: Neurocognitive Assessment in Concussion and Return to Duty, to the DHB Psychological Health External Advisory Subcommittee by Dr. Robert Kane, June 16, 2011.

20. Presentation: Policy Overview: Baseline Neurocognitive Assessments, to the DHB Psychological Health External Advisory Subcommittee by Ms. Elizabeth Fudge, June 16, 2011.

21. Reeves DL, Winter KP, Bleiberg J, Kane RL. ANAM Genogram: Historical perspectives, descriptions, and current endeavors. Achieves of Clinical Neuropsychology, 22 Suppl, 15-27, 2007.

22. Bleiberg J, Cernich A, Cameron K, Sun W, Peck K, Eckland J, Reeves D, Uhorchak J, Sparling M, Warden D. Duration of Cognitive Impairment After Sports Concussion. Neurosurgery, 54, 1073-1080, 2004.

23. Warden DL, Bleiberg J, Cameron KL, Ecklund J, Walter J, Sparling MB, Reeves D, Reynolds KY, Arciero R. Persistent prolongation of simple reaction time in sports concussion. Neurology, 57, 524-526, 2001.

24. Bleiberg J, Kane RL, Reeves D, Garmoe WS, Halpern EL. Factor analysis of computerized and traditional tests used in mild brain injury research. The Clinical Neuropsychologist, 14(3), 287-294, 2000.

25. Kane RL, Roebuck-Spencer T, Short P, Kabat M, Wilen J. Archives of Clinical Neuropsychology, 22Suppl. d115-S126, 2007.

26. Luethcke CA, Bryan CJ, Morrow CE, Isler WC. Comparison of concussive symptoms, cognitive performance, and psychological symptoms between acute blast-versus nonblast-induced mild traumatic brain injury. Journal of the International Neuropsychology Society, 17, 1-10, 2011.

27. Marion DW, Curley KC, Schwab K, Hicks RR, and the mTBI Diagnostics Workgroup. Proceedings of the Military in mTBI Diagnostics Workshop, St. Pete Beach, August 2010. Journal of Neurotrauma, 28(4), 517-526, 2011.

28. Wright JK, Zant E, Groom K, Schlegel RE, GIllilard K. Case Report: Treatment of mild traumatic brain injury with hyperbaric oxygen. Undersea Hyperbaric Medicine, 36(6), 391-399, 2009

29. Ivins BJ, Kane R, Schwab KA. Performance on the Automated Neuropsychological Assessment Metrics in a nonclinical sample of soldiers screened from mild TBI after returning from Iraq and Afghanistan: a descriptive analysis. Journal of Head Trauma Rehabilitation, 24(1), 24-31, 2009.

30. Committee on Gulf War and Health: Brain Injury in Veterans and Long-Term Health Outcomes. Gulf War and Health: Volume 7: Long-Term Consequences of Traumatic Brain Injury. Washington, D.C.: Institute of Medicine of the National Academies. 2008. Retrieved from: http://www.nap.edu/catalog.php?record_id=12436

31. Scientific Advisory Panel. Use of the Automated Neuropsychological Assessment Metric. October 2-3, 2007. Retrieved from: http://www.health.mil/dhb/meetings/2007-12/NC-Assessment-Tool-Advisory-Panel-Report.doc